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Technical Report No. 5
CU-59-2 Nonr 266(37) Geology

THE LONG TERM RECORDER

LAMONT GEOLOGICAL OBSERVATORY
Columbia University
Palisades, New York

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TECHNICAL REPORT NO. 5

CU-59-2 Nonr 266(37) Geology

THE LONG TERM RECORDER

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January 1959

ABSTRACT

A small battery operated microfilm recorder for geophysical signals with periods longer than one second is described. It is capable of operating for periods of a month or more without attention. Enlargements of typical records and construction blueprints are included.

ACKNOWLEDGEMENTS

Mr. Walter Beckmann, geophysicist, and Mr. Angelo Ludas, machine shop foreman, did an effective job of transforming the original Long Term Recorder model into a unit suitable for limited production and field use at International Geophysical Year stations.

INTRODUCTION

This report describes a photographic recorder designed by W. R. Horsfield of Warwick, Bermuda to meet the general requirements of Professor Maurice Ewing, Columbia University, for a remote battery operated recorder. Tidal, seismic, geomagnetic, and barometric phenomena may be recorded with this instrument. Important considerations when recording such geophysical signals are:

(1) The signal periods (i.e. the reciprocal of the signal frequency) are all longer than one second.

(2) Recording stations are often at isolated locations so that a battery operated recorder with a low power consumption is needed.

(3) Multiple identical stations facilitate the study of geophysical phenomena by making it possible to compare records directly without concern for phase or amplitude characteristics.

(4) Recorders must often be operated by local untrained personnel, such as are found at the IGY locations mentioned below.

The recorder described herein was developed in the spring of 1956. It is at present being used by the Lamont Geological Observatory in their IGY Island Observatory Program, with recorders at Iceland, the Azores, Barbados, Bermuda, Mauritius, Texas Tower No. 4 ,and Belmar, N. J.

The major problem in developing such a geophysical recorder is the problem of reliable automatic time marks when operating on batteries alone. We have not yet adequately solved this problem in an economical manner.

This recorder is one step in the program, at Lamont Geological Observatory, to develop an undersea recording seismograph which will operate for one year without attention.

PRINCIPLES OF OPERATION

Figures 1, 2 ,and 3 show various views of the recorder. The carrying case shown in Figure 1 serves as a light tight box for the optical system. Basically, operation is as follows; the image of the illuminated tip of the indicating arm of a standard electric meter is focused by a microscope objective lens on 35 mm film. This image is swept across the short dimensions of the film which advances between sweeps. Details of the recorder operation are:

(1) The electrical meter used is dependent upon the signal to be recorded. For small amplitudes these small portable meters have a uniform response from DC to periods of one or two seconds.

(2) The tip of the meter arm is coated with:

a) High intensity self-luminous phosphor such as Undark yellow-70M. No other illumination is required. Such a light source used with TRI X film developed at a rating of 200, gives a record such as Figure 4. It is suitable for use at slow sweep speeds such as 1" per 2 hours for recording tidal or barometric phenomena.

b) White paint, illuminated by a small light bulb. The holder into which the light bulb is inserted may be seen in Figure 2 to the right and just above the tip of the meter arm. A record of this type is shown in Figure 5. For this type of illumination maximum sweep speed is determined by the meter's response and the optical resolution of the system. Light shielding may be required for the film.

(3) The microscope objective is mounted at the end of a 6" lens arm that pivots along a line through the moving meter arm tip that is to be photographed. The cam that sweeps the microscope objective at constant speed across the film, by lifting the lens arm, may be seen in Figure 2 and 3, to the left and below the 35 mm film cassette. This motion gives a sweep length of about 1" across the short dimension of 35 mm film.

(4) Upon reaching the top of this constant motion cam, the lens arm drops to start a new sweep. The lens arm dropping action provides the power to advance the film by means of the link lever fastened to the lens arm pivot and the link rod that may be seen on the near side of the recorder in Figure 2.

(5) Microscope objectives of 10X, 21X, or 43X may be used to vary the photograph reduction between the meter arm tip and the film image. The short depth of focus of these microscope objectives necessitate the film being held in an arc against the curved film guide plate so that the lens-film distance remains constant.

(6) Figure 1 shows the position of the film just before the carrying case cover is to be closed for operation. (The film holder lid is beside the recorder). After closing the cover the film is wound, using the film sprocket and a handle through the case cover, into the circular film holder that may be seen to the left of the microscope objective in Figure 1. As the lens arm falls it returns the film to the original commercial film cassette after the record is made. Prior to opening the carrying case all unused film is returned to the cassette by the same handle.

(7) The recorder may be focused by either of two methods utilizing a small hole through the front plate. The hole makes it possible to see the image of the meter arm tip on the film. In practice the microscope lens tube is loosened and adjusted for proper focus by:

a) Viewing the image of the meter arm tip on a strip of clear film by means of the hole in the front plate behind the film.

b) Placing a piece of scratched film in the recorder, illuminating it from behind by a light bulb through the hole in the front plate until the image of the film scratches are focused at the plane of the meter arm tip, as seen on a small piece of translucent white paper. Using 21X and 43X objectives, the grain of the film may be used for most critical focusing with this method.

DISCUSSION

The versatility of this recorder is illustrated by the possible combinations of sweep speed, film advance per sweep, meter sensitivity, method of meter tip illumination, microscope objective power, and film speed. The relative insensitivity of the meter movement to high frequency signals probably limits the records to about 10 cps.

As mentioned in the introduction, accurate time from a DC power source is a problem in an inexpensive recorder. The LTR of Figure 1 used a 60 cps alternating current, 3 watt synchronous motor for drive power. This type of small timing motor is made in an assortment of speeds by the A.W. HAYDON COMPANY or the R.W. CRAMER COMPANY. We are at present experimenting with various small DC motors that will have adequate speed control and running life. Mr. Horsfield's initial attempt at DC timing utilized a surplus British mine clock to pulse a Sigma Rotary ratchet relay. Such a drive method of course, meant that the sweep translated in small increments rather than smoothly. We are at present experimenting with the small DC chronometer motors of the type manufactured by the EL PRODUCTS COMPANY and the R. W. CRAMER COMPANY.

An alternate method, originating with Dr. Ewing, for providing precise time ticks on a battery operated recorder, is to utilize the approximate bi-weekly seismic P-wave signals of strong earthquakes as the time ticks to rate the DC powered drive motion. The precision of such P-wave arrivals can be computed to an accuracy of approximately one second anywhere on earth.

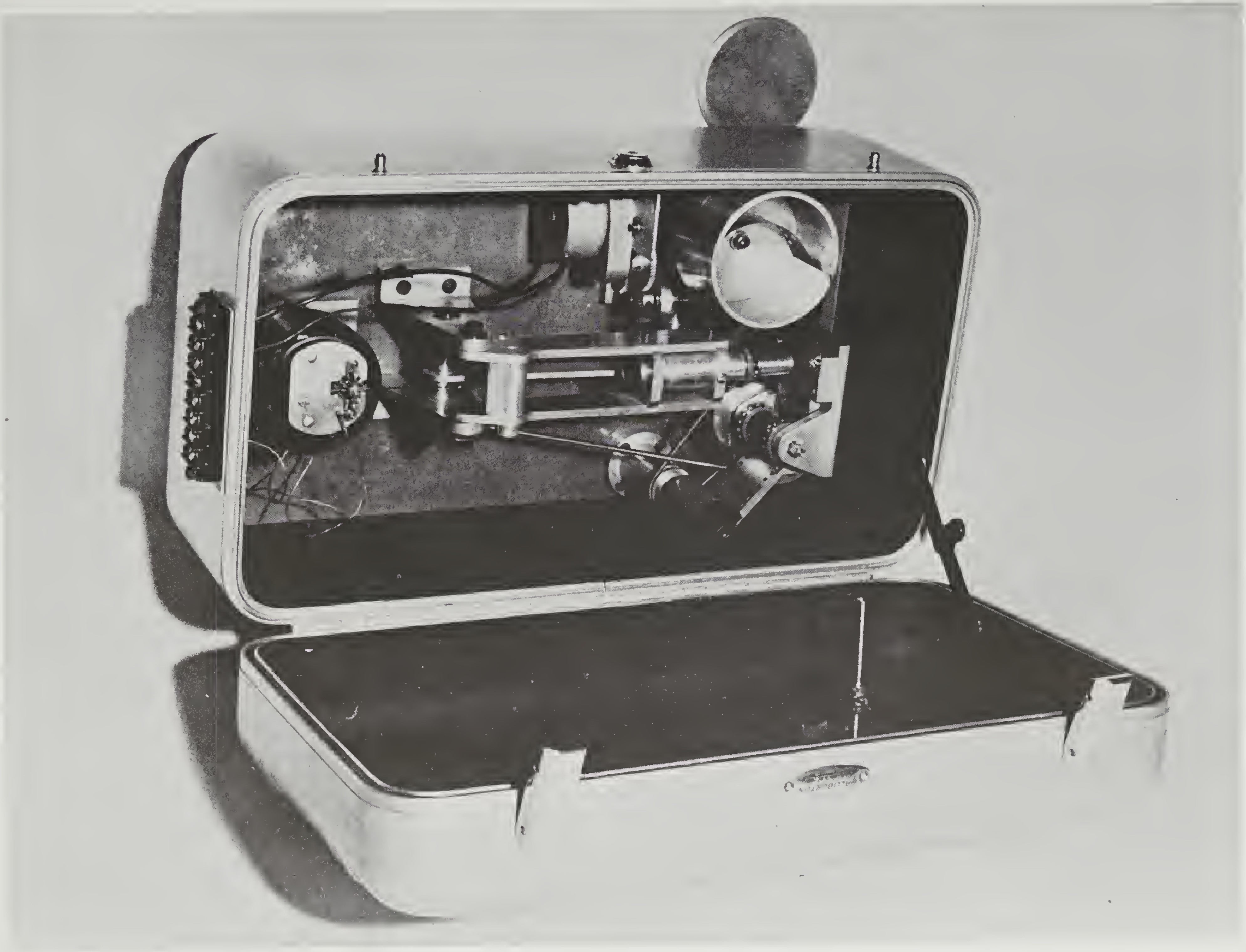


Figure 1. Long Term Recorder as mounted in light tight carrying case.

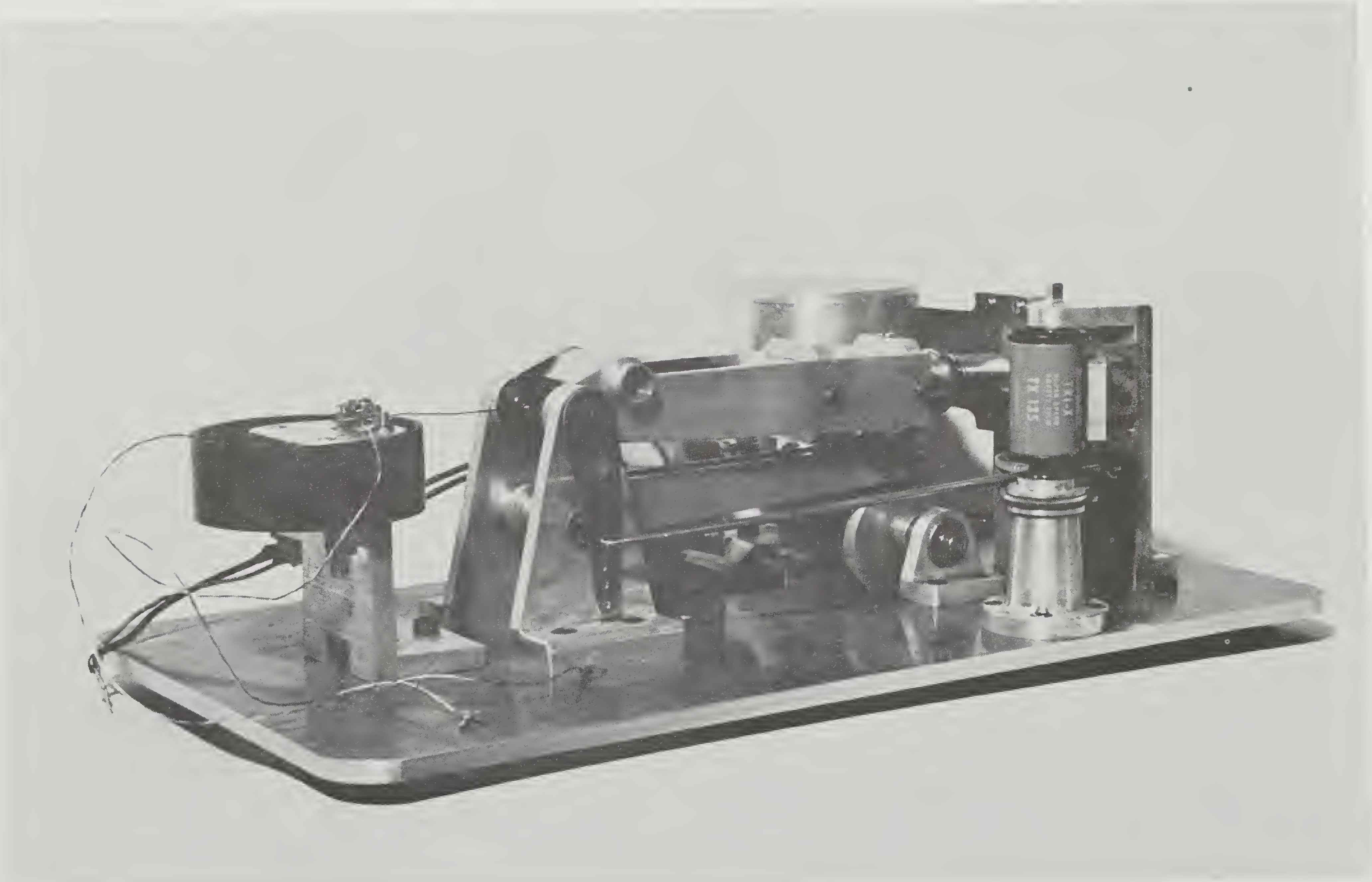


Figure 2. Side view of Long Term Recorder mechanism.

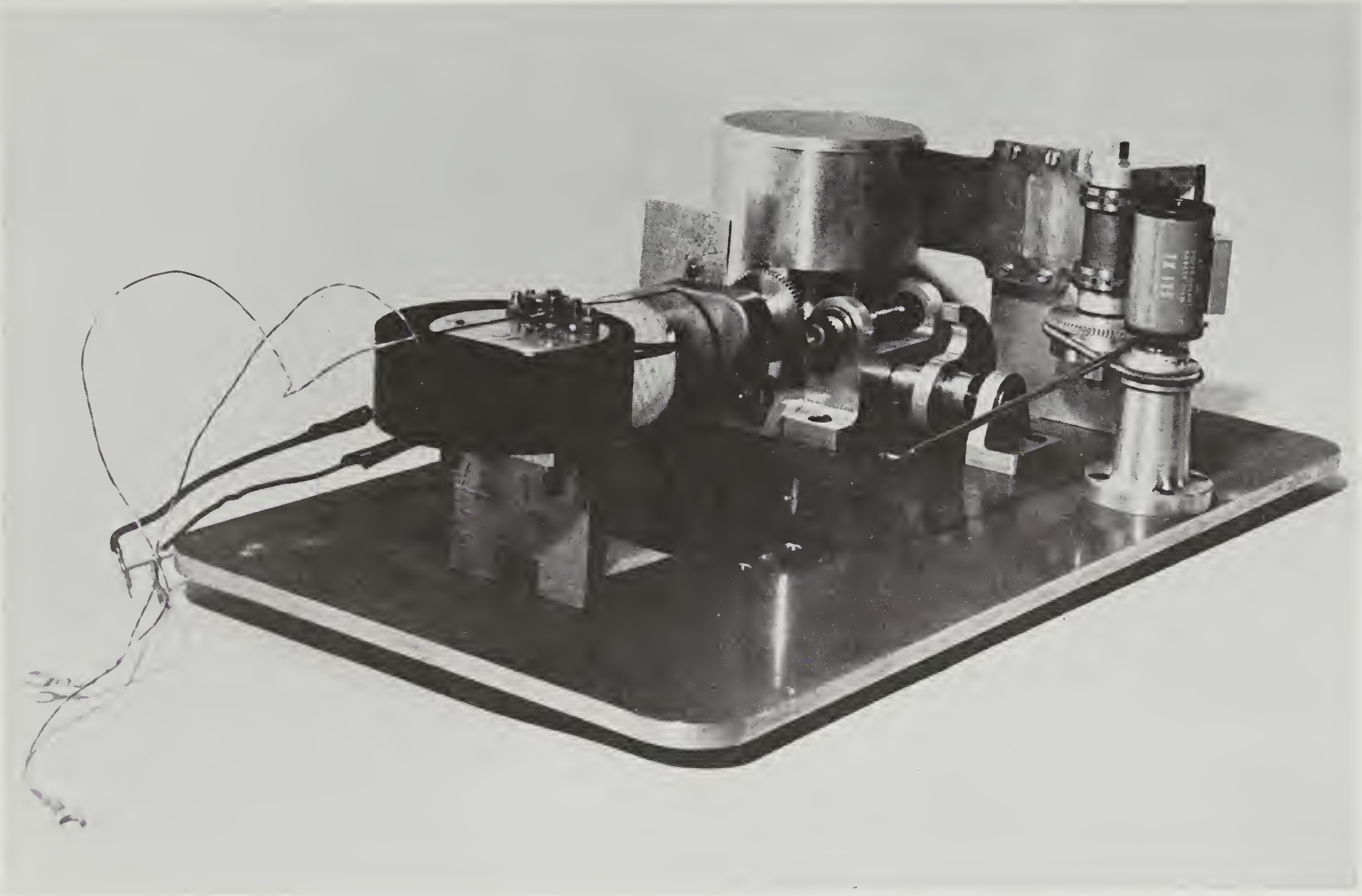


Figure 3. Long Term Recorder with lens arm removed.

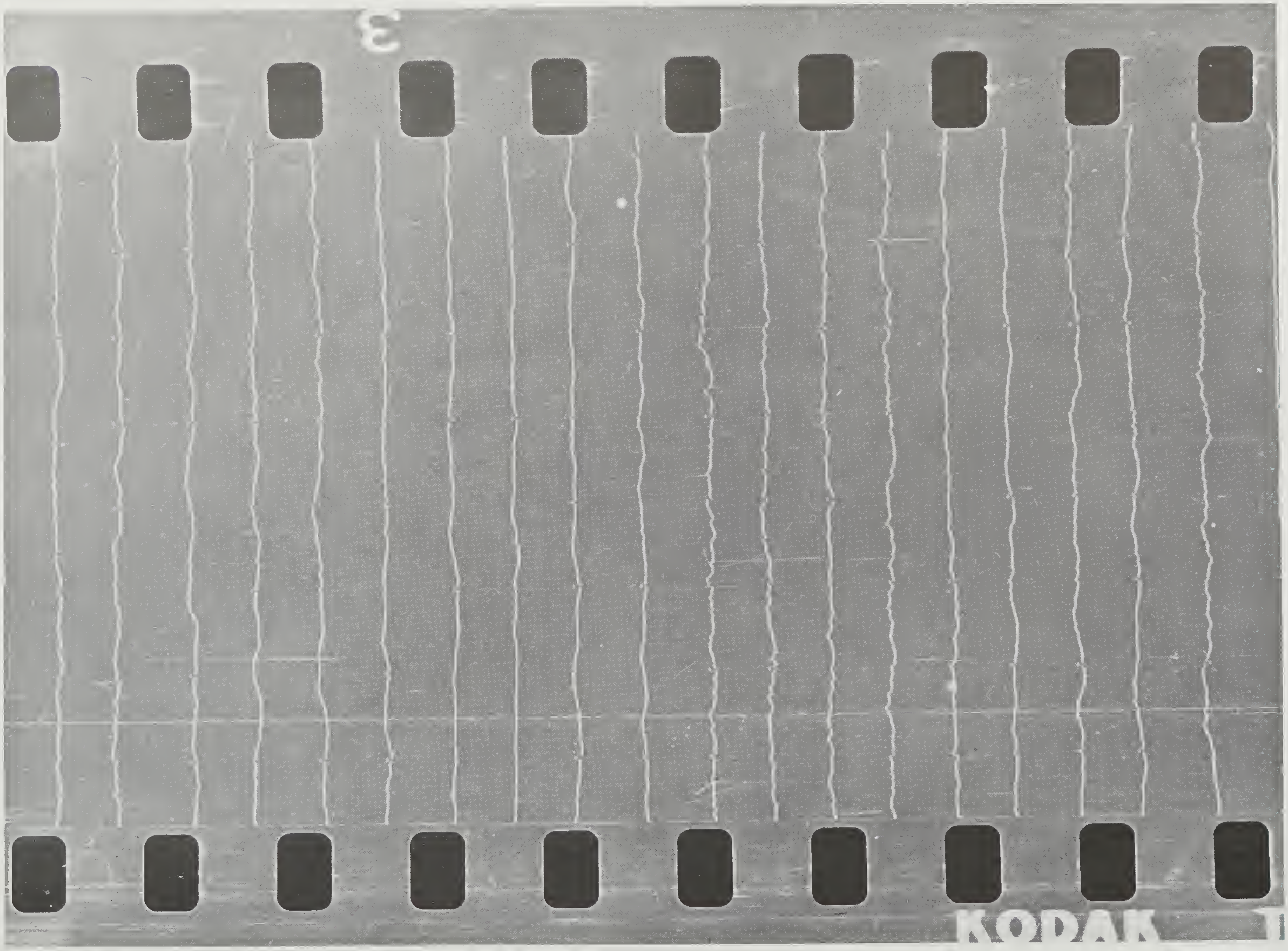


Figure 4. Long Term Recorder record of a microbarovariograph, using a two hour sweep. Lens-21X microscope objective; film-TRI-X; illumination-needle tipped with self-luminous radioactive paint; time mark every 15 minutes.

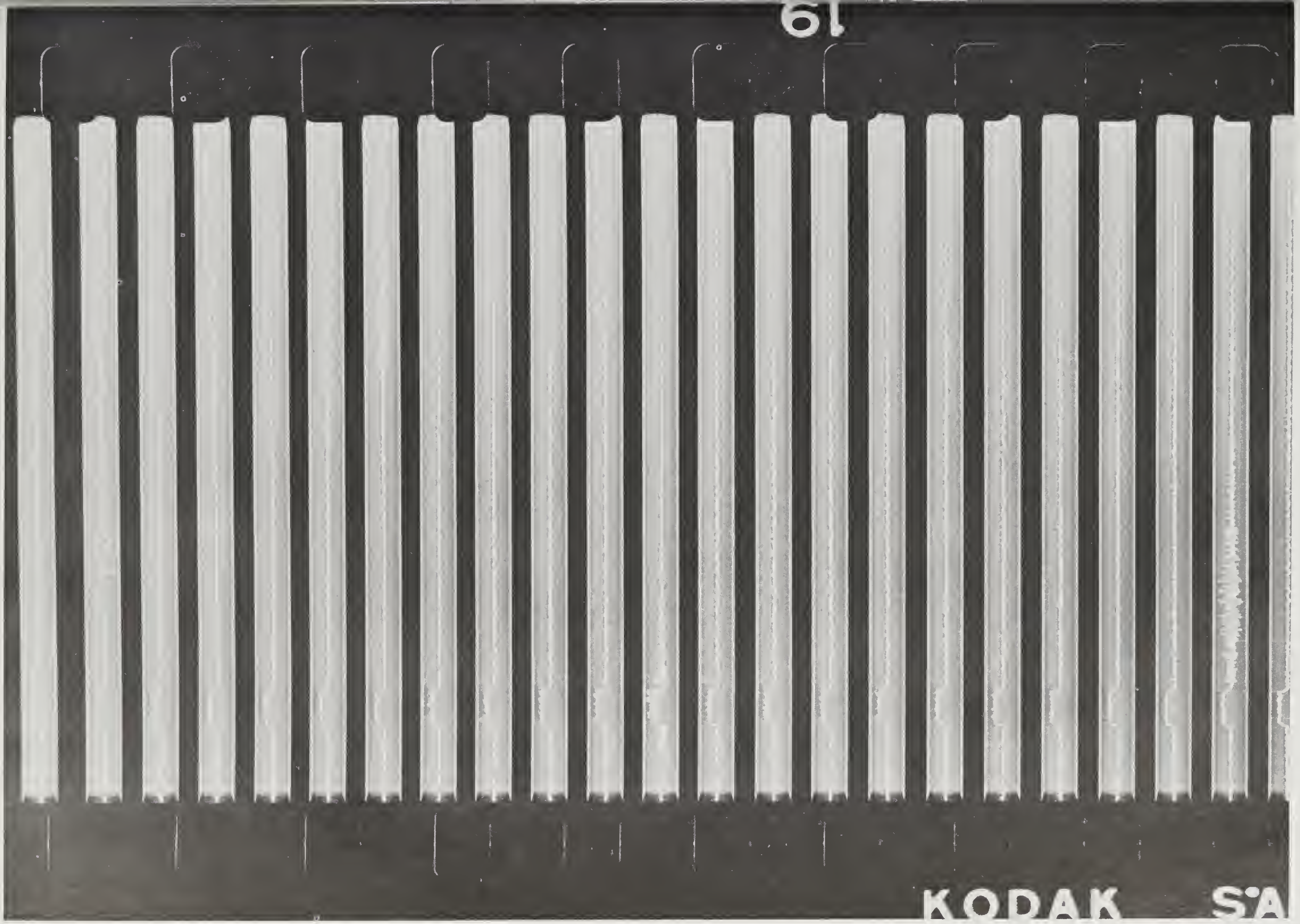


Figure 5. Long Term Recorder record of a 1 second seismograph, using a 1 minute sweep. The three shocks are distant TNT blasts with signals of 4 to 6 cycles per second. Lens-21X microscope objective; film-TRI-X; illumination-6 volt flashlight bulb; time marks-one per minute.

SCHEDULE OF PARTS

Part No.	Sheet No.	Map Ref.	DESCRIPTION	MATERIAL	NUMBER REQUIRED
1	2	DA	Base Plate	1/4" Alum Plt.	1
2	2	H3	Film Guide & Sprocket Bracket(Back Plate)	Alum	1
3	2	F5	Cam Shaft Bearing Bracket	Alum	1
4	2	G10	Cam Shaft & Worm Wheel Bearing Bracket	Alum	1
5	2	K9	Cam Lever	Alum	2
6	2	B11	Lens Arm Bracket	Alum	2
7	2	D11	Lens Arm	3/16 Alum Plt.	2(Opp Handed)
8	2	B16	Film Holder	Alum	1
9	2	F14	Film Holder Lid	5/16 Alum Plt.	1
10	2	J13	Film Guide Arm	Alum	1
11	2	A17	Front Lens Tube Holder	Alum	1
12	2	C17	Rear Lens Tube Holder	Alum	1
13	2	G17	Shim Film Guide	Brass Shim .008" Thick	1
14	3	C1	Meter Mount	Alum	1
15	3	F1	Cassette Shaft Base	Alum	1
16	3	B4	Meter Mount Cover	Alum	1
17	3	D5	Lens Tube	Stainless Steel	1
18	3	EA	Bulb Holder	Alum & 1/64" Brass Sht.	1
19	3	H3	Motor Bracket Clamp	Alum	1
20	3	A7	Cam Rider Block	Teflon or Nylon	1
21	3	C8	Cam Shaft	Stainless Steel	1
22	3	D9	Film Guide Plate	Alum	1
23	3	H9	Motor Bracket	Alum	1
24	3	K2	Cassette Shaft	Stainless Steel	
25	3	J8	Worm Shaft	Stainless Steel	1
26	3	K8	Motor Drive Shaft	Stainless Steel	1
27	3	D6	Cam Shaft Securing Bush	Alum	1
28	3	F8	Link Lever	Stainless Steel	1
29	3	B9	Clutch Casing	Alum	1
30	3	D10	Clutch	Brass	1

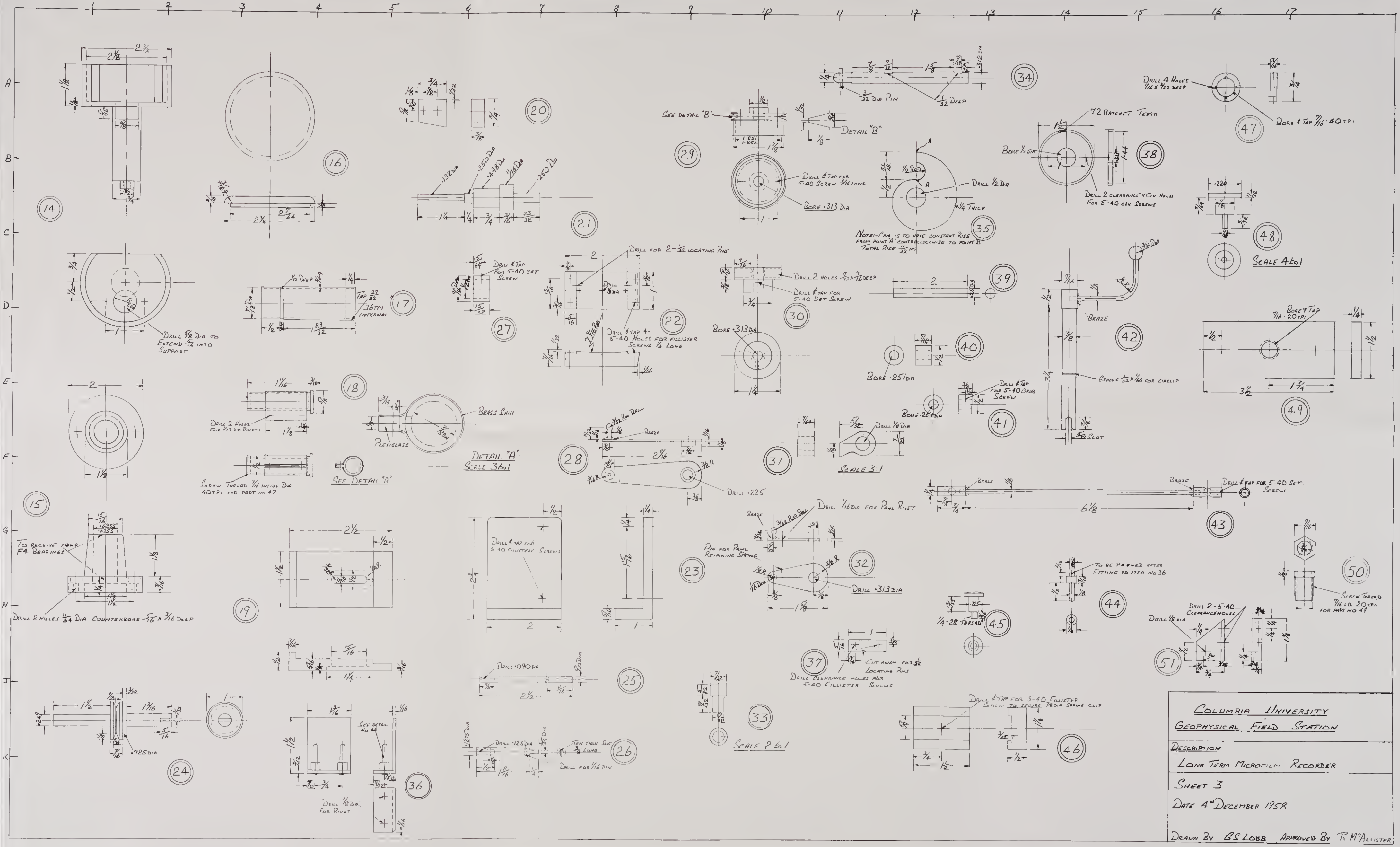
SCHEDULE OF PARTS

Part No.	Sheet No.	Map Ref.	DESCRIPTION	MATERIAL	NUMBER REQUIRED
31	3	F10	Ratchet Pawl	Stainless Steel	2
32	3	G11	Film Advance Ratchet Arm	Stainless Steel	1
33	3	J10	Clutch Pad	Leather	2
34	3	A13	Clutch Shaft	Stainless Steel	1
35	3	B13	Cam	Alum	1
36	3	K5	Film Shield	Alum	1
37	3	J11	Film Guide Adjustment Strips	Brass	2
38	3	B15	Clutch Ratchet Wheel	Brass	1
39	3	D13	Cam Lever Shaft	Alum	1
40	3	E13	Cam Lever Spacer Bush	Alum	2
41	3	F13	Cam Lever Securing Bush	Alum	1
42	3	D15	Rewind Handle	Stainless Steel	1
43	3	H16	Link Rod	Stainless Steel	1
44	3	H15	Film Shield Rivet	Stainless Steel	1
45	3	H13	Lens Arm Securing Screw	Brass	2
46	3	K14	Lens Arm Weight	Brass	1
47	3	A17	Bulb Holder Nut	Brass	1
48	3	C17	Pawl Rivet	Stainless Steel	2
49	3	E17	Rewind Handle Securing Plate	Steel	1
50	3	G17	Rewind Handle Bushing	Brass	1
51	3	J16	Pawl Securing Bracket	Brass	1
52	ND		Bausch & Lomb Optical Co. Objective Lens, 8 MM 1.50 21 X # WN1125	S.P.	1
53	ND		Boston Gear # 1024, Bore-3/16 Dia, 48 Pitch 60 Teeth, Pitch Dia. 1.250	S.P.	1
54	ND		Boston Gear # LSH, Bore-3/16" Dia, 48 Pitch $14\frac{1}{2}^{\circ}$, Pitch Dia. .333"	Steel	1
55	ND		Halliburton Model 101 X Case 16" X 19 X 8"	S.P.	1
56	ND		Simpson Electric Co. Meter, Mod. 25,27,29; Zero Center Movement	S.P.	1
57	ND		Film Spool, Simplex # W-145-D	S.P.	1
58	ND		Bushing Nut, 3/8-32 Half Nut	S.P.	1
59	ND		Dialco Miniature Bayonet Socket Bracket Mounted	S.P.	1

SCHEDULE OF PARTS

Part No.	Sheet No.	Map Ref	DESCRIPTION	MATERIAL	NUMBER REQUIRED
60	ND		Knurled Knob For Film Holder Cover	S.P.	1
61	ND		8 Contact Barrier Terminal Strip		
62	ND		1/8" Dia. Coiled Spring Belt, $6\frac{1}{4}$ long	S.P.	1
63	ND		Pawl Retaining Spring	Spring Wire	2
64	ND		7/8 Clip For Objective Arm Weight	Spring Steel	1
65	ND		1" Spherical Base Plate Mounting Support	Rubber	3
66	ND		Fafnir F 4 Bearings	S.P.	8
67	ND		Screws	S.P.	As Req'd

N.D. Not Drawn
S.P. Standard Part



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J
K
14
15
16
17
Drill 5/8 Dia to Extend 1/2 into Support
1/32 Deep
Tap 27/32 36 TPI Internal
18
Drill 2 Holes For 1/32 Dia Rivets
Screw Thread 7/16 inside Dia 40 T.P.I. for part no 47
See Detail "A"
Brass Shim
Plexiglass
Detail "A" Scale 3 to 1
19
To Receive Fafnir F4 Bearings
Drill 2 Holes 1/64 Dia Counterbore 5/16 x 3/16 Deep
20
21
.130 Dia
.250 Dia
.498 Dia
.250 Dia
22
Drill for 2-1/32 Locating Pins
Drill & Tap 4-5-40 Holes for Fillister Screws 1/4 Long
23
Drill & Tap for 5-40 Fillister Screws
24
.725 Dia
25
Drill .090 Dia
26
Drill .125 Dia
Ten Thou Slot 3/4 Long
Drill for 1/16 Pin
27
Drill & Tap For 5-40 Set Screw
28
3/32 Rad Ball
Braze
Drill .225
29
See Detail "B"
Detail "B"
Drill & Tap for 5-40 Screw 3/16 Long
Bore .313 Dia
30
Drill 2 Holes 7/32 x 7/16 Deep
Drill & Tap for 5-40 Set Screw
Bore .313 Dia
31
Drill 1/8 Dia
Scale 3:1
32
Drill 1/16 Dia for Pawl Rivet
Braze
3/32 Rad Ball
Pin for Pawl Retaining Spring
Drill .313 Dia
33
Scale 2 to 1
34
3/32 Dia Pin
1/32 Deep
.312 Dia
35
Drill 1/2 Dia
1/4 Thick
1/2 Rad
Note:- Cam is to have constant rise from point A' contraclockwise to point B' Total Rise 11/32 ins
36
See Detail No 44
Drill 1/8 Dia For Rivet
37
Cut away for 1/32 Locating Pins
Drill Clearance Holes for 5-40 Fillister Screws
38
72 Ratchet Teeth
Bore 1/2 Dia
Drill 2 Clearance & Csk Holes For 5-40 csk Screws
39
40
Bore .251 Dia
41
Drill & Tap For 5-40 Grub Screw
Bore .251 Dia
42
3/16 Dia
Braze
Groove 1/32 x 1/64 for circlip
5/32 Slot
43
Braze
Braze
Drill & Tap for 5-40 Set Screw
6 1/8
44
To be Peened after Fitting to item No 36
45
1/4-28 Thread
46
Drill & Tap for 5-40 Fillister Screw to secure 3/8 Dia Spring Clip
47
Drill 4 Holes 1/16 x 3/32 Deep
Bore & Tap 7/16-40 T.P.I.
48
Scale 4 to 1
49
Bore & Tap 7/16-20 TPI
50
Screw Thread 7/16 O.D. 20 T.P.I. For part no 49
51
Drill 1/8 Dia
Drill 2-5-40 Clearance Holes

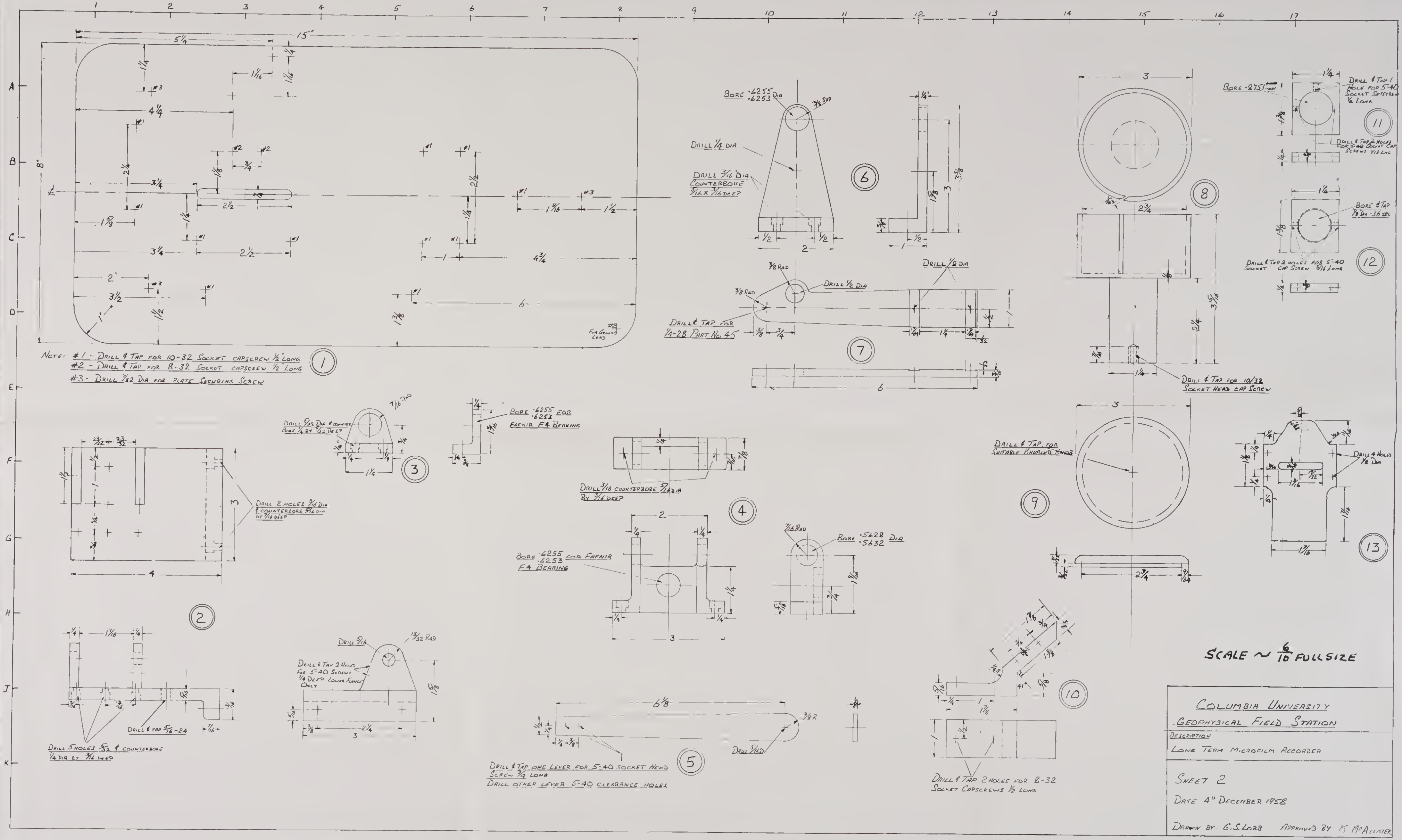
Columbia University
Geophysical Field Station

Description
Long Term Microfilm Recorder

Sheet 3

Date 4th December 1958

Drawn By G S Lobb Approved By R McAllister

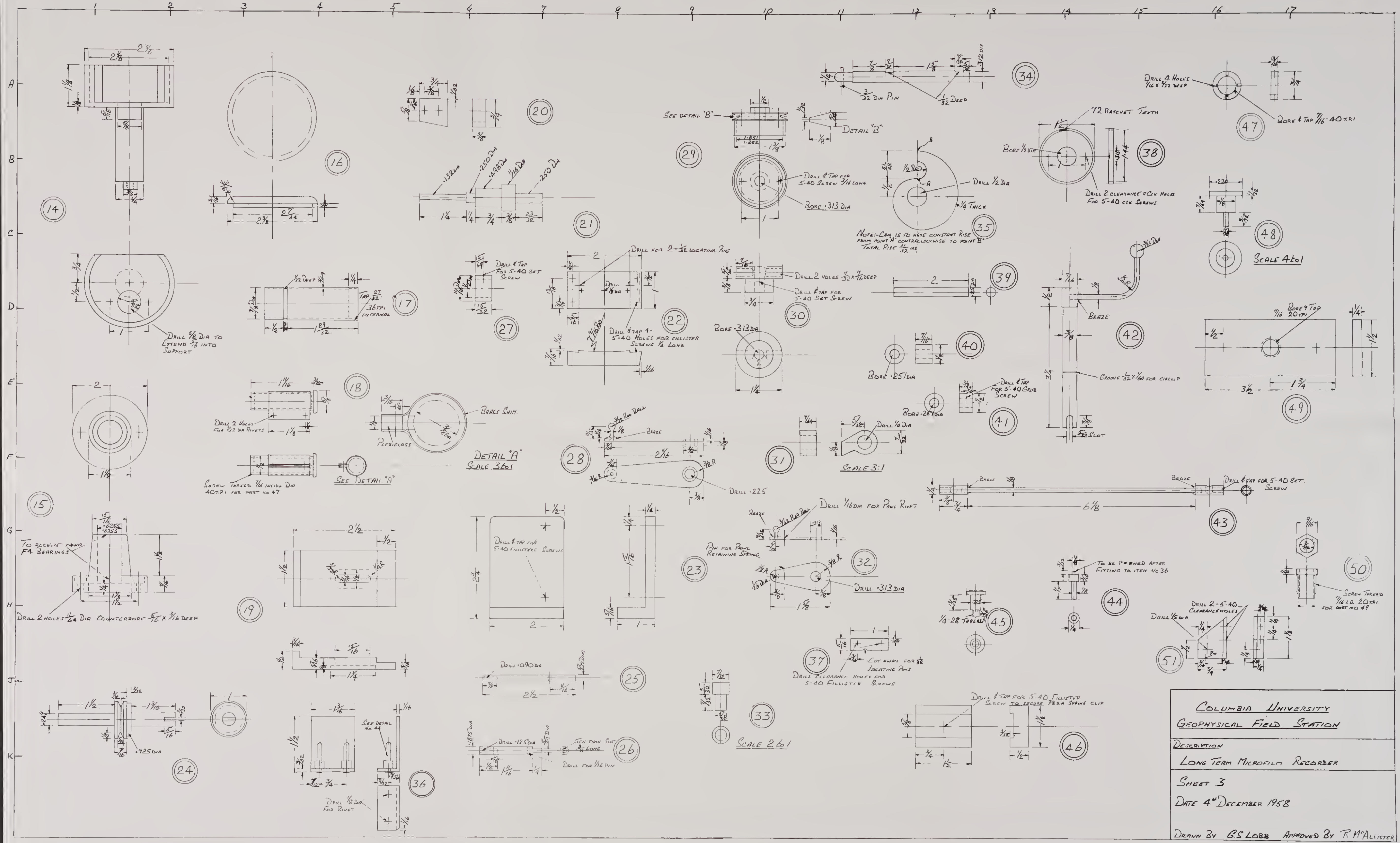

15"
5¼
8"
Note: #1 - Drill ¢ Tap for 10-32 Socket capscrew ½" Long
#2 - Drill ¢ Tap for 8-32 Socket capscrew ½" Long
#3 - Drill 7/32 Dia for plate Securing Screw
For Ground Lead
①
Bore .6255 .6253 Dia
3/8 Rad
Drill ¼ Dia
Drill 3/16 Dia Counterbore 5/16 x 7/16 deep
⑥
3/8 Rad
Drill ½ Dia
Drill 1/8 Dia
Drill ¢ Tap for ¼-28 Part No 45
⑦
Bore .8751
Drill ¢ Tap 1 Hole for 5-40 Socket Setscrew ⅛ Long
Drill ¢ Tap 2 Holes for 5-40 Socket Cap Screws 7/16 Long
⑪
Bore ¢ Tap ⅞ Dia - 36 thd
Drill ¢ Tap 2 holes for 5-40 Socket Cap Screw 3/16 Long
⑫
⑧
Drill ¢ Tap for 10/32 Socket Head cap Screw
Drill 5/32 Dia ¢ counter Bore ¼ by 5/32 Deep
7/16 Rad
③
Bore .6255 .6253 for Fafnir F4 Bearing
Drill 3/16 counterbore 5/16 dia by 7/16 deep
④
Bore .6255 .6253 for Fafnir F4 Bearing
7/16 Rad
Bore .5628 .5632 Dia
Drill ¢ Tap for Suitable Knurled Knob
⑨
Drill 4 Holes ⅛ Dia
⑬
Drill 2 holes 7/16 Dia ¢ counterbore 5/16 dia by 7/16 deep
②
Drill 5/16
13/32 Rad
Drill ¢ Tap 2 Holes for 5-40 Screws ¼ Deep Lower Flange Only
Drill ¢ tap 5/16-24
Drill 5 holes 5/32 ¢ counterbore ¼ dia by 3/16 deep
6⅛
3/8 R
Drill 5/16 D
Drill ¢ Tap one Lever for 5-40 Socket Head Screw ¾ Long
Drill other lever 5-40 clearance holes
⑤
⑩
Drill ¢ Tap 2 Holes for 8-32 Socket Capscrews ½ Long

SCALE ~ $\frac{6}{10}$ FULLSIZE

COLUMBIA UNIVERSITY
GEOPHYSICAL FIELD STATION

DESCRIPTION
LONG TERM MICROFILM RECORDER

SHEET 2
DATE 4th DECEMBER 1958
DRAWN BY - G. S. LOBB APPROVED BY R. McALLISTER



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
A B C D E F G H J K
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51
Drill 5/8 Dia to Extend 5/8 into Support
To receive Fafnir F4 Bearings
Drill 2 Holes 1/64 Dia Counterbore 5/16 x 3/16 Deep
Drill 2 Holes For 1/32 Dia Rivets
Screw Thread 7/16 inside Dia 40 T.P.I. for part No 47
See Detail "A"
Brass Shim
Plexiglass
Detail "A" Scale 3 to 1
Tap 27/32 36 TPI Internal
Drill & Tap For 5-40 Set Screw
Drill for 2-1/32 Locating Pins
Drill & Tap 4-5-40 Holes for Fillister Screws 1/8 Long
Drill & Tap for 5-40 Fillister Screws
Braze
Drill .225
Drill .090 Dia
Drill .125 Dia
Slot thru Slot 3/8 Long
Drill for 1/16 Pin
See Detail No 44
Drill 1/8 Dia For Rivet
See Detail "B"
Detail "B"
Drill & Tap for 5-40 Screw 3/16 Long
Bore .313 Dia
Drill 2 Holes 7/32 x 7/16 Deep
Drill & Tap for 5-40 Set Screw
Bore .313 Dia
Drill 1/16 Dia for Pawl Rivet
Pin for Pawl Retaining Spring
Drill .313 Dia
Scale 2 to 1
Drill Clearance Holes for 5-40 Fillister Screws
Cut away for 3/32 Locating Pins
3/32 Dia Pin
1/32 Deep
1/2 Rad
Drill 1/2 Dia
1/4 Thick
Note:- Cam is to have constant rise from point A' contraclockwise to point B'. Total Rise 11/32 ins
Bore .251 Dia
Bore .251 Dia
Drill & Tap for 5-40 Grub Screw
Drill 1/8 Dia
Scale 3:1
1/4-28 Thread
To be peened after fitting to item No 36
Drill & Tap for 5-40 Fillister Screw to secure 3/8 Dia Spring Clip
72 Ratchet Teeth
Bore 1/2 Dia
Drill 2 Clearance & Csk Holes for 5-40 Csk Screws
Braze
Groove 1/32 x 1/64 for Circlip
Slot
Drill & Tap for 5-40 Set Screw
Drill 4 Holes 1/16 x 3/32 Deep
Bore & Tap 7/16-40 T.P.I.
Scale 4 to 1
Bore & Tap 7/16-20 TPI
Screw Thread 7/16 I.D. 20 T.P.I. for part No 49
Drill 1/8 Dia
Drill 2-5-40 Clearance Holes

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SHEET 3
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DRAWN BY G.S. LOBB APPROVED BY R. McALLISTER

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